R E M A R K S

Independent claims 1 and 35 have been amended to incorporate, respectively, the recitals of dependent claims 14 and 44, which have accordingly been cancelled as redundant, with corresponding changes made in the dependence of claims 15 and 45. Claim 17 has been rewritten in independent form to include all the limitations of original claim 1 on which it was heretofore dependent. Independent claim 18 has been amended to clarify its recital of certain novel and distinguishing features of the invention. New independent claim 46 has been added, combining the recitals of original claims 18 and 19. A marked-up copy of the amended claims, headed "Version with Markings to Show Changes Made," is attached hereto. Since this Amendment increases by two the number of independent claims, a check in payment of the requisite additional fee of $168 is submitted herewith.

Claims 1 - 13, 15 - 43, 45 and 46 are in the application. Claims 1, 17, 18, 35 (all amended) and 46 (new) are independent; claims 2 - 13, 15 and 16 are dependent on 1; claims 19 - 34 are dependent on 18; and claims 36 - 43 and 45 are dependent on 35. All the claims have been finally rejected under 35 U.S.C. §103(a) as unpatentable over Thorburn et al. in view of Kush, with which Dumont-Fillon et al. is combined in the rejection of claims 7 and 24.

Independent claim 1 as herein amended is substantively identical to cancelled dependent claim 14 as previously presented; independent claim 17 as herein amended is substantively identical to dependent claim 17 as previously presented; independent claim 18 as herein amended includes a recital that the cooling and guiding apparatus contacts the reverse surface of the one casting belt within the mold region (the added recital being supported by the original disclosure e.g. at pp. 8-10 of the specification); independent claim 35 as herein amended is substantively identical to cancelled dependent claim 44 as previously presented; and new

independent claim 46 is substantively identical to dependent claim 19 as previously presented.

The grounds of rejection of the claims will be discussed below.

Claims 1 and 35

Each of amended independent claims 1 (belt cooling and guiding apparatus) and 35 (nozzle) recites, *inter alia*, a nozzle having a support surface for supporting or facing a reverse surface of a casting belt, a continuous slot in the support surface for delivery of cooling liquid, and a drainage opening spaced from the continuous slot for removal of cooling liquid,

> "wherein said support surface is beveled away from said reverse surface at outer edges of said nozzle to form a bevel adjacent to each of said outer edges."

This bevel is shown at **70** in FIG. 5 of applicants' drawings. As the specification explains (p. 13, lines 4-8),

> "The purpose of this beveled configuration is to create conditions whereby the cooling liquid flow in the horizontal direction through the expanding gap between the belt and the nozzle surface creates an additional local volume which assists in belt stabilization . . . ."

More particularly, referring to the slope of the load/standoff curves of FIG. 7, the specification notes (p. 14, lines 7-10) that

> "A high slope is a very desirable characteristic for a nozzle because it tends to stabilize the position of the belt and the flow of cooling liquid, which in turn stabilize the heat transfer"

and observes (p. 14, lines 26-27) that

> "The slope of the curve at the operating point, representing the resistance to perturbation of belt position, is greatest for the beveled configuration"

adding (p. 15, lines 2-3) that "the preference is to lean towards a design having the best belt stability." Thus, the bevel recited

in claims 1 and 35 has an important effect and is not a mere matter of design choice.

In the final Office Action it is asserted (p. 3, numbered paragraph 4) that Thorburn et al. discloses nozzle elements "beveled from the reverse surface of the belt." The only "bevel" shown or described by Thorburn et al., however, is the central dishing of the face of the hexagonal nozzle shown in FIGS. 2 and 3, as to which Thorburn et al. states (col. 6, lines 8-10) that "it is usually desired to have a slightly depressed configuration, e.g. tapered very slightly toward the central opening **54**." Apart from other differences between the nozzle structures of Thorburn et al. and those of the present claims, the dishing or inward taper ***toward the center*** in Thorburn et al. is the antithesis of "***beveled*** away from said reverse surface ***at outer edges*** of said nozzle to form a bevel ***adjacent to each of said outer edges***" as recited in amended claims 1 and 35. Thus, Thorburn et al. clearly does not teach this structural feature (bevel adjacent to each outer edge of a nozzle) to which amended claims 1 and 35 are limited.

The final Office Action further asserts (p. 6, numbered paragraph 7) that "changes in the geometric provisions of Thorburn et al." would be obvious from Thorburn et al. alone. But nothing is seen in the teaching of Thorburn et al. to suggest modifying even the disclosed nozzle of Thorburn et al. by providing a bevel adjacent to outer edges of the nozzle (either instead of, or in addition to, dishing the nozzle face toward a central coolant delivery opening). Much less would that teaching indicate, to a person of ordinary skill in the art, how or where to bevel a nozzle having a continuous slot for delivery of cooling liquid.

Furthermore, there is nothing in Thorburn et al. to indicate that the bevel of applicants' amended claims 1 and 35 would provide the significant beneficial results, with respect to improved belt stabilization, described in applicants' specification and discussed above. Those results are accordingly unex-

pected, and as such are entitled to weight in determining patentability.

Certainly Kush et al., which contains no disclosure of any bevel feature, adds nothing to Thorburn et al. in this regard.

Therefore it is submitted that the specific beveling feature recited in each of amended claims 1 and 35 is a novel and unobvious structural feature that distinguishes both claims patentably over Thorburn et al. and Kush, however combined. Claims 2 - 13, 15 and 16, and claims 36 - 43 and 45, are believed allowable with amended claims 1 and 35, on which they are respectively dependent. Dumont-Fillon et al., cited only for the filter recited in dependent claim 7, does not supply what is lacking in Thorburn et al. and Kush with respect to the bevel structure defined in amended claim 1.

Claim 17

Claim 17 (belt cooling and guiding apparatus), rewritten in independent form to incorporate the limitations of claim 1, recites, *inter alia*, at least one elongated nozzle having a support surface facing a reverse surface of a casting belt, a continuous slot in the support surface for delivery of cooling liquid, and a drainage opening spaced from the continuous slot for removal of cooling liquid, "wherein an array of point cooling nozzles is provided downstream of said at least one elongated nozzle provided with said slot." As the specification explains (p. 10, lines 21-31),

> "The region of the apparatus where a high degree of transverse uniformity of cooling is essential (rather than merely preferable) has been found to be limited to the front section of the casting mold from a position (in the direction of advancement of the belts) where the molten metal first contacts the casting belts and volatilization of liquid belt dressing (when used) may occur, to a position where uniform solidification is no longer critical to the surface and internal quality of the cast strip. While further cooling is required downstream of this front section of the mold, conventional cooling may be used in this downstream region.

> Thus, as shown in Fig. 2, immediately following the slotted nozzles 30, the support and cooling of the belt may be provided by a plurality of resiliently-mounted hexagonal-sided nozzles 34 of the type disclosed in [Thorburn et al.] . . . having central openings 35 for injection of cooling liquid . . . ."

There is nothing in Thorburn et al. or Kush that suggests that the use of slot and point sources of cooling liquid together (as defined in claim 17) is advantageous or would even work. The two references respectively use point source and slot nozzles for belt cooling, but they respectively place these different types of nozzles in very different locations, and use in combination is not obvious as a result.

It follows that the recital in claim 17 of the combination of slot and point source nozzles (with the latter downstream of the former) presents a novel, unobvious and patentable structural distinction over Thorburn et al. and Kush, whether considered separately or together.

Claim 18

The invention defined in amended claim 18 involves the modification of the belt cooling and support arrangement of Thorburn et al. to include one or more nozzles provided with a slot extending transversely of a casting belt of a twin belt caster. This assures uniformity of cooling transversely of the belt as the metal is introduced into the casting mold. Thorburn et al. uses a plurality of hexagonal "point source" nozzles and does not in any way suggest the provision of an elongated transverse slot. On the other hand, Kush is not concerned with belt support, only with belt cooling outside the casting zone (as the belt loops around to re-enter the mold). However, Kush does disclose the concept of using an elongated transverse slot to direct cooling liquid onto the belt surface (there are also slots for containment fluid and gas).

Claim 18 has been amended to make clear that the belt cooling and guiding apparatus contacts the belt(s) on the reverse surfaces

within the mold region. This is a feature of structure (disposition of the cooling and guiding apparatus in relation to other elements of the claimed caster) and is in contrast to Kush where the cooling apparatus is on the return loop and offers no belt support.

It is noted that, in the present invention, the belt must pass close enough to the nozzle to allow support through a film of cooling liquid flowing over the nozzle. There will be no support if this "standoff" distance is so great that air may intrude, as may be the case in Kush. It is the combination of the continuous slot nozzle, and the vacuum and drainage system acting on the reverse surface of the belt, that achieves a uniformity of coolant layer thickness and velocity that is essential in the present invention, but not apparently necessary or present in Kush.

Since Kush provides a method and apparatus intended only for quenching a belt in a region remote from the casting cavity, there is no need for Kush to use the quenching apparatus to define the casting cavity and no need to deal with solidifying metal. For example, if Kush were applied to only one side of the belt (a possible reading of the broadest description of Kush), there is nothing in the reference that suggests that a belt being impinged on only one side by coolant in the perpendicular direction, by containment fluid in an angled direction and by containment gas would retain its position reliably or for that matter that such an arrangement could be used near the casting cavity. If one uses the Kush preferred embodiment using a cooling box on both sides of the belt, it would of course be impossible to place this near the casting cavity. It is only in this sort of configuration that one might argue by symmetry that the belt would remain in a "stable" position and one could not use such a configuration in the mold region.

The Examiner comments that once coolant flow reaches "steady state" it is "uniform" and as Kush operates in steady state, it too would imply uniformity of coolant flow. A steady state flow is

uniform only in that volume flow rate of coolant has presumably reached some final value.

The present invention requires that the coolant form a continuous film of uniform thickness and velocity of flow across the belt and this is recited in claim 18. This is a stricter requirement than the uniformity implied by a steady state flow. Kush teaches that the coolant flows from the nozzle perpendicular to the belt, impinges on the belt and moves in a generally longitudinal direction thereafter, until it shortly encounters the containment fluid and is diverted into the removal channels. Unless the coolant, being a liquid, is contained by more than one surface, it will not generally be of uniform thickness, gravity and other forces having their inevitable effect. Therefore, there is nothing in Kush that suggests that use of a longitudinal slot nozzle will result in a coolant film of uniform thickness. Thorburn et al. is also described by the Examiner as teaching that a uniform flow is achieved. The portion of the reference (col. 9) cited by the Examiner does not actually make this assertion, and as Kush provides no teaching that a uniform thickness arises from the use of a slot-like nozzle, a person of ordinary skill in the art would not be led by the references to assume that substitution of a slot for a hexagonal nozzle would add any uniformity to the Thorburn et al. system or even retain any uniformity that might have existed.

Kush also fails to teach that uniformity of velocity is achieved. Even if the flow rate of a coolant is uniform, the velocity is dependent on the coolant cross-sectional area as well, and even in steady state it is not necessarily uniform. In fact, the Kush apparatus, using containment streams and gases, is clearly designed to disrupt the coolant flow and prevent any development of uniform velocity. The Thorburn et al. apparatus, by its dependence on "point source" coolant injection, is incapable of achieving uniform coolant velocity in the transverse direction of the belt, and since the Kush apparatus would not be capable of this and indeed is intended to cause turbulence and not uniform

velocities by use of the containment streams, one would not apply the Kush slot arrangement to the Thorburn et al. apparatus to achieve a uniform velocity.

The rejection also fails to take into account the differences between quenching and temperature control. The Kush apparatus operates on a casting belt away from the critical casting cavity and is intended to efficiently bring the belt temperature down to a defined temperature by the time the belt exits the cooling apparatus. As such the use of coolant containment fluids that interact with the coolant stream can be highly advantageous at increasing the turbulence and heat transfer capability of the coolant.

In the present invention, the cooling system operates in the mold region (i.e., the region of the casting cavity) and it is important to maintain control of the temperature of the belt along a length of the cavity. For this reason, geometric uniformity of coolant flow is important, and the uniformity of the coolant velocity and as a result the spatial uniformity of the heat transfer coefficient is important. This represents a very different problem from cooling a belt to a desired temperature and one that is not addressed by Kush.

Kush is of course combined with Thorburn et al. Thorburn et al. deals with the general problem of applying coolant flow through a series of point source nozzles to a system that is in some ways similar to the present invention. Thorburn et al. has as an objective the achievement of temperature control in the casting cavity. The reference does not specifically teach that a uniformity of coolant film thickness is achieved and it is clear that by its nature a uniform velocity is not possible. Systems of the type taught by Thorburn et al. operate by a balance of hydrodynamic forces and the forces developed in the casting belt passing over the coolant nozzles. This balance is complex and there is nothing suggested in Thorburn et al. that a shift from point source coolant application to a transverse linear coolant application would, when combined with the longitudinal and

transverse forces arising within the casting belt, provide the desired uniformity in the transverse direction.

As Kush does not teach a structure suitable for use in the area of the casting cavity, and since Kush does not teach that a slot nozzle can create uniformity of coolant thickness or velocity, and finally since nothing in Thorburn et al. would lead one to believe that changing from a point source coolant inlet to a continuous slot would be workable or advantageous, it would not be obvious to the artisan of ordinary skill to combine their teachings to arrive at the invention of claim 18.

In summary, the Examiner contends that a person of ordinary skill in the art would be motivated to modify the Thorburn et al. cooling arrangement in light of Kush so as to achieve (in the Thorburn et al. system) the advantage of improved containment taught by Kush. Kush, however, teaches use of a transversely slotted "nozzle" only for containment and only in combination with obliquely directed curtains of containment fluid; moreover, Kush is exclusively concerned with removing heat from the belts at a location separated from the coating zone or mold region, and does not indicate that a stand-off layer of coolant liquid fills the entire gap between belt and nozzle surface. There is nothing in either reference to suggest that the Kush arrangement, if positioned in the casting mold region, could provide the feature of controlled support (stand-off) required for the Thorburn et al. type of operation.

Consequently, the recital herein added to claim 18, that the cooling and guiding apparatus (provided with the transversely arranged continuous elongated slot) contacts the belt reverse surface ***within the mold region***, presents a clear and patentable structural distinction over Kush, Thorburn et al. and any proper combination thereof.

Claims 19 - 34 are submitted to be allowable by virtue of their dependence on amended claim 18. Again, Dumont-Fillon et al.

(cited against claim 24) adds nothing to the other references with respect to the novel and distinguishing features of claim 18.

Claim 46

Added claim 46 corresponds to original claim 19 rewritten in independent form to incorporate all the original recitals of claim 18 on which original claim 9 was dependent. As such, claim 46 may be considered as having been finally rejected, like claim 19, on Thorburn et al. in view of Kush.

Claim 46 does not include the "mold region" recital added herein to claim 18 (and discussed above), but instead, like original claim 19, recites that a first nozzle (provided with a transversely arranged continuous elongated slot) is positioned (i.e., "for engaging a reverse surface of said one casting belt") ***immediately adjacent to the entrance of the casting mold***.

This, again, constitutes a positional (hence, structural) feature of the claimed apparatus that would not be obvious from Thorburn et al. or Kush or any proper combination of the two, for reasons similar to those set forth above in the discussion of amended claim 18. Kush shows use of an elongated transverse slot only in combination with containment features that could not be used or provided immediately adjacent to the entrance of the casting mold, where considerations of belt support are critical. The asserted motivation for modifying Thorburn et al. in view of Kush ("in order to relieve pressure and to contain quenching fluid from longitudinally escaping along the belt surface," final Office Action, p. 4, last paragraph) is negated by the fact that the containment function is provided by the Kush slot only in combination with other features that are incompatible with the provision of the stable belt support required when the nozzle is ***immediately adjacent to the entrance of the casting mold***, as claim 46 recites.

Claim 46 is therefore submitted to distinguish patentably over Thorburn et al. and Kush, considered together.

For the foregoing reasons, it is believed that this application is now in condition for allowance. Favorable action thereon is accordingly courteously requested.

Respectfully,

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I hereby certify that this paper is being deposited this date with the U.S. Postal Service as first class mail addressed to Assistant Commissioner for Patents, Washington, D.C. 20231.

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS:

Claims 1, 15, 17, 18, 35 and 45 have been amended as follows:

1. (Amended) A belt cooling and guiding apparatus for a casting belt of a twin belt caster provided with a pair of rotatably supported endless casting belts, a casting mold formed between moving casting surfaces of confronting generally planar sections of the belts, said sections having reverse surfaces opposite said casting surfaces, the casting mold having a molten metal entrance at one end and a solidified sheet article outlet at an opposite end, and a casting injector for introduction of molten metal into the casting mold at the entrance of the casting mold; the cooling and guiding apparatus comprising at least one elongated nozzle having a support surface facing a reverse surface of said casting belt, a continuous slot in the support surface arranged transversely substantially completely across said casting belt for delivery of cooling liquid to the reverse surface of said belt in the form of a continuous film having a substantially uniform thickness and velocity of flow when considered in the transverse direction of the belt, a drainage opening for removal of cooling liquid at a position spaced from said continuous slot, and a vacuum system associated with said drainage opening for applying suction to said drainage opening<u>, wherein said support surface is beveled away from said reverse surface at outer edges of said nozzle to form a bevel adjacent to each of said outer edges</u>.

15. (Amended) The apparatus of claim [14] 1, wherein said bevel extends inwardly from said outer edges towards said slot by a distance of from 2.5 mm to 3.5 mm.

17. (Amended) [The] A belt cooling and guiding apparatus [of claim 1], for a casting belt of a twin belt caster provided with a pair of rotatably supported endless casting belts, a casting mold formed between moving casting surfaces of confronting generally planar sections of the belts, said sections having reverse surfaces opposite said casting surfaces, the casting mold having a molten metal entrance at one end and a solidified sheet article outlet at an opposite end, and a casting injector for introduction of molten metal into the casting mold at the entrance of the casting mold; the cooling and guiding apparatus comprising at least one elongated nozzle having a support surface facing a reverse surface of said casting belt, a continuous slot in the support surface arranged transversely substantially completely across said casting belt for delivery of cooling liquid to the reverse surface of said belt in the form of a continuous film having a substantially uniform thickness and velocity of flow when considered in the transverse direction of the belt, a drainage opening for removal of cooling liquid at a position spaced from said continuous slot, and a vacuum system associated with said drainage opening for applying suction to said drainage opening, wherein an array of point cooling nozzles is provided downstream of said at least one elongated nozzle provided with said slot.

18. (Amended) A twin belt caster comprising a pair of rotatably supported endless casting belts, a casting mold formed between moving casting surfaces of confronting generally planar sections of the belts, said sections having reverse surfaces opposite said casting surfaces, the casting mold having a molten metal entrance at one end and a solidified sheet article outlet at an opposite end, and a casting injector for introduction of molten metal into the casting mold at the entrance of the casting mold,

said one end and said opposite end defining a mold region between them; said caster including cooling and guiding apparatus for at least one of said casting belts, comprising at least one nozzle having a support surface, for engaging a reverse surface of said one casting belt, provided with a continuous elongated slot arranged transversely substantially completely across said one casting belt for delivery of cooling liquid to the reverse surface of said belt in the form of a continuous film having substantially uniform thickness and velocity of flow when considered in the transverse direction of the belt, a drainage opening for removal of cooling liquid spaced from said continuous slot, and a vacuum system associated with said drainage opining for applying suction to said drainage opening, wherein said cooling and guiding apparatus contacts said reverse surface of said one casting belt within said mold region.

35. (Amended) A nozzle for a belt cooling and guiding apparatus, comprising a support surface for supporting a reverse surface of a casting belt, the support surface having a length corresponding to a width of said belt, an elongated continuous slot in said support surface having a length substantially the same as the length of the support surface for delivery of cooling liquid in the form of a continuous film having uniform thickness and velocity of flow along the slot, and a drainage opening for removal of cooling liquid spaced from said continuous slot, wherein said support surface is beveled away from said reverse surface at outer edges of said nozzle to form a bevel adjacent to each of said outer edges.

45. (Amended) The nozzle of claim [44] 35, wherein said bevel extends inwardly from said outer edges towards said slot by a distance of from 2.5 mm to 3.5 mm.